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REPORT NO. 53888

SIMULATION TEST REPORT FOR THE MULTIPLE DOCKING ADAPTER PACKAGE-FASTENING DEVICES

By Manufacturing Research and Technology Division
Manufacturing Engineering Laboratory

September 12, 1969

NASA

George C. Marshall Space Flight Center
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By

Manufacturing Research and Technology Division

George C. Marshall Space Flight Center
Huntsville, Alabama

ABSTRACT

An evaluation of design concepts for package-fastening devices was conducted in the Manufacturing Engineering Laboratory's zero "g" engineering mock-up. The tests were performed on the following items: (1) Douglas Aircraft Corporation's (DAC) grid and hook fasteners, (2) the Martin Company's Deutch screw, (3) McDonnell Aircraft Corporation's captive screw, and (4) Marshall Space Flight Center's (MSFC's) quick release nut.

The DAC grid and hook package-fastening device was the optimum design concept in the neutrally buoyant environment.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER

SIMULATION TEST REPORT FOR THE MULTIPLE DOCKING ADAPTER PACKAGE-FASTENING DEVICES

By

Manufacturing Research and Technology Division
Manufacturing Engineering Laboratory

Manufacturing Engineering Laboratory
Research and Development Operations

ACKNOWLEDGMENT

This publication is based on tests conducted in the Manufacturing Engineering Laboratory's zero "g" engineering mock-up to meet the requirements established in a Simulation Support Request (SSR-MDA-1) issued by the Engineering Analysis Section (R-P&VE-VAE), Systems Engineering Branch, Vehicle Systems Division of the Propulsion and Vehicle Engineering Laboratory.

J. G. Tisdale of the RCA Service Company compiled the information.

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SIMULATION TEST REPORT FOR THE MULTIPLE DOCKING ADAPTER PACKAGE-FASTENING DEVICES

INTRODUCTION

A human factor evaluation of the Multiple Docking Adapter (MDA) package-fastening device design concepts was conducted in the zero "g" engineering mock-up of the Manufacturing Engineering Laboratory to determine the optimum fastening device. Package-fastening device concepts were submitted by Douglas Aircraft Corporation (grid and hook fasteners), the Martin Company (Deutch screw), McDonnell Aircraft Corporation (captive screw), and Marshall Space Flight Center (quick-release nut).

Four test subjects in shirt-sleeve environment (SCUBA gear) performed the test October 4-6, 1967.

DISCUSSION

The simulation test hardware consisted of a vertical aluminum test stand with interchangeable task panels with simulated packages attached to the work area. A detachable grid task panel (Fig. 1) was used with the DAC concept. A detachable aluminum task panel (Fig. 2) was used for the other design concepts. The simulated packages were fabricated of plexiglass and attached to the panels on tubular frames. This provided a restricted work area such as would be encountered in the flight hardware. The single restraint used was Dutch shoes.

The Douglas grid and hook concept shown in Figure 1 utilized two hooks (bolts with oversized heads) in the lower corners and a fastener that is remotely operated by depressing a button above the handle on the front of the box (see insert). This package is also shown in Figure 3.

The other experiment package (Fig. 4) had four captive screw devices (McDonnell) and provision for inserting the Deutch screw (Martin) and quick release (MSFC) devices on four flanged sides (Figs. 5 and 6).

The simulation test procedure (STP-MDA-N/B-1) that was written for the evaluation of the MDA Package Fastening Devices was not followed. The Douglas package-fastening concept was broken during the first test run by the first test subject and was deleted from the task sequence until repairs could be made. The test engineer introduced variables not included in the Simulation Test Procedure.

The test procedure for test subject 1 consisted in the test subject's positioning himself in a foot restraint device in front of the test stand and dismounting an experiment package from the task board mounted on the test stand. Each fastener concept was tested twice with the exception of the Douglas concept, which was broken during the first dismounting test. The test subject was unsuccessful in dismounting the package fastened with four McDonnell captive screws. The top and bottom screws were difficult for the test subject to reach because the package obscured his vision of the fasteners. It was also hard for the test subject to determine when the hand tool and the screws were engaged. The test subject had no trouble with Martin's Deutch screws. The MSFC quick-release nut was unfastened without complications.

The test procedure for test subject 2 included variations that were not done by test subject 1. Each concept tested was evaluated with the test subject's using foot restraints and again without his using foot restraints. The test subject was unable to evaluate the Douglas design concept because it was broken. The order of testing included the McDonnell, the Martin, and the MSFC concept's, consecutively. Only two of the four captive screws (the McDonnell concept), one on the left and one on the right side of the package, were used. The test subject was able to dismount the package, but he still had two main problems: (1) inability to know when the tool and the screw were engaged and (2) inability to determine when the screw had been released. The test subject performed the test on the Martin concept without a hand tool and again with the tool. The conclusion was that the concept was easier to operate without a hand tool. No trouble was experienced while operating with the Martin or MSFC concepts.

The procedure followed by test subject 2 was also used by test subject 3. The test subject found that it was difficult to insert the tool in the proper screw location to disengage the McDonnell captive screw. The test subject also found it difficult to determine when the screw was actually disengaged from the test stand. The test subject found it easier and faster to unfasten the

Deutch screw by hand than with the optional tool. The MSFC quick-release nut was operated with ease. Test subject 3 concluded that each concept was easier to operate with the aid of foot restraints.

The same procedure that was used by test subjects 2 and 3 was followed by test subject 4. The test subject had the same complaints about the McDonnell captive screw concept, plus two more: (1) It required the use of both hands to manipulate the hand tool. (2) The tool had to be turned too many times before the screw could be disengaged. Test subject 4 objected to having to hold the Deutch screws while unfastening the other screws and suggested that they be attached to the package by a chain or some other retaining device. The same objection was expressed about the MSFC quick-release nut. Both the Martin Deutch screw and the MSFC quick-release nut concepts were easy to operate.

Repair work on the Douglas fastening device was completed, reinstalled on the test stand, and readied for design evaluation. Each task was evaluated with the test subject's wearing foot restraints and again without his wearing foot restraints. Test subject 4 concluded that the Douglas concept was the easiest one to operate.

Following the same procedure used by test subject 4, test subject 2 returned October 6 to evaluate the Douglas concept. The test subject concluded that it was a well-thought-out approach and the easiest concept to unfasten. The test subject suggested that the hooks on the bottom of the package be redesigned to provide additional strength and ensure a more positive alignment with the grid assembly.

The following task timetables (Tables I-IV) illustrate how long it took each test subject to perform a task:

CONCLUSIONS

By studying Tables I through IV, the following conclusions can be made:

1. All concepts were operated faster with the aid of foot restraints.

2. The Martin Deutch screw can be operated faster without a tool.

3. The test subjects performed the tests faster as they gained experience.

4. The Douglas concept was operated in less time than the other three concepts. The time required for operating the Martin Deutch screws and the MSFC quick release nuts was approximately the same. The McDonnell captive screw takes longer to unfasten than any of the other concepts.

RECOMMENDATION

In an underwater neutrally buoyant environment the Douglas hook and grid package-fastening design concept device can be operated with speed and ease. It is superior to the other three concepts tested under the same conditions. Further testing of the Douglas hook and grid concept is recommended to evaluate the stress/strength qualifications needed for satisfactory operation in the environments anticipated in the MDA.

TABLE I. TEST SUBJECT 1 (BOBBY JOE CAIN) OCTOBER 4, 1967, 10:30 A. M.

Concept	Run 1	Run 2
Douglas	Two fasteners broke off during dismount.	Subject was not tested because is was broken.
McDonnell	Unsuccessful. Test stopped after 8 minutes.	Unsuccessful. Test stopped after 6 minutes.
Martin	16 sec.	8 sec.
MSFC	13 sec.	8 sec.

TABLE II. TEST SUBJECT 2 (RICHARD HECKMAN), OCTOBER 4, 1967, 2:30 P.M.

Concept	Run 1	Run 2	Run 3	Run 4
Douglas	Not tested because of broken fastener	Not tested because of broken fastener	Not tested	Not tested
McDonnell	35 sec.	37 sec.	1 min. 30 sec.	Not tested
Martin	25 sec.	21 sec.	Without tool, 24 sec. With tool, 49 sec.	Not tested
MSFC	25 sec.	23 sec.	24 sec.	Not tested
Douglas (After repairs)				Dismount with foot restraints 4 sec. Mount with foot restraints 2 min. 1 sec. Dismount with foot restraints 4 sec. Mount with foot restraints 52 sec. Dismount/mount with foot restraints 17 sec.

TABLE II. (Cont'd)

Concept	Run 1	Run 2	Run 3	Run 4	
Douglas (After repairs)				Dismount without foot restraints	6 sec.
				Mount without foot restraints	1 min. 3 sec.
				Dismount without foot restraints	6 sec.
				Mount without foot restraints	38 sec.
				Dismount/mount without foot restraints	49 sec.

Test Variations:
1. Only two of the four fasteners were used when testing McDonnell's concept
2. Run 3 was done without foot restraints.
3. Martin's Deutch screw was tested without and with the optional tool.
4. The package-mounting task was performed on only one of the four fastening design concept devices (Douglas concept).

Test Subject 2 returned on October 6, 1967 at 8:00 A. M. to test Douglas concept.

TABLE III TEST SUBJECT 3 (CHARLES TORSTENSON), OCTOBER 5, 1967, 9:30 A.M.

Concept	Run 1	Run 2	Run 3
Douglas	Not tested	Not tested	Not tested
McDonnell	3 min.	52 sec.	1 min.
Martin	53 sec.	53 sec.	Without tool, 53 sec. With tool, 58 sec.
MSFC	51 sec.	52 sec.	25 sec.

Test Variations: 1. Only two of the four fasteners were used when testing McDonnell's concept.

2. Run 3 was done without foot restraints.
3. Martin's Deutch screw was tested without and with the optional tool.

TABLE IV. TEST SUBJECT 4 (CHARLES COOPER), OCTOBER 5, 1967, 1:00 P. M.

Concept	Run 1	Run 2	Run 3	Run 4	
Douglas	Not tested	Not tested	Not tested	Not tested	
McDonnell	2 min.	1 min.	56 sec.	Not tested	
Martin	21 sec.	20 sec.	Without tool, 20 sec. With tool, 43 sec.		
MSFC	17 sec.	19 sec.	21 sec.	Not tested	
Douglas (After repairs)				Dismounting with foot restraints	2 sec.
				Dismounting with foot restraints	2 sec.
				Dismount followed by mounting using foot restraints	35 sec.
				Dismount followed by mounting using foot restraints	24 sec.
				Mounting using foot restraints	20 sec.
				Mounting using foot restraints	25 sec.

TABLE IV. (Cont'd)

Concept	Run 1	Run 2	Run 3	Run 4	
Douglas (After repairs)				Dismounting without foot restraints	5 sec.
				Mounting without foot restraints	22 sec.
				Dismounting without foot restraints	5 sec.
				Mounting without foot restraints	24 sec.
				Dismounting without foot restraints	6 sec.
				Mounting without foot restraints	22 sec.

Test Variations:
1. Only two of the four fasteners will be used when testing McDonnell's concept.
2. Run 3 was done without foot restraints.
3. Martin's Deutch screw was tested without and with the optional tool.
4. The package mounting task was performed on only one of the four fastening design concept devices (Douglas concept).

The Douglas concept was tested last because repair work was being done on the package while the other design concept devices were being tested.

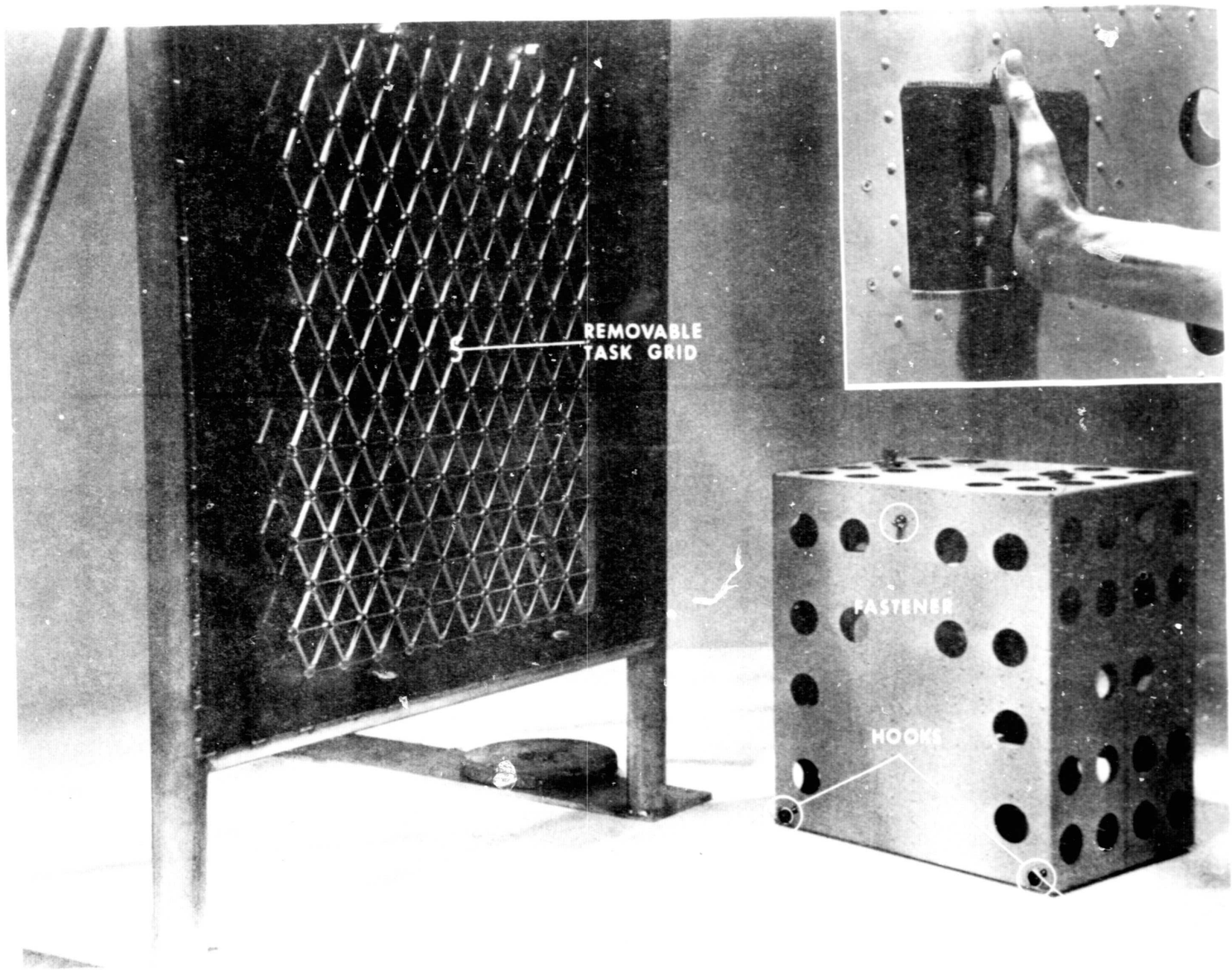

FIGURE 1. DETACHABLE GRID TASK PANEL

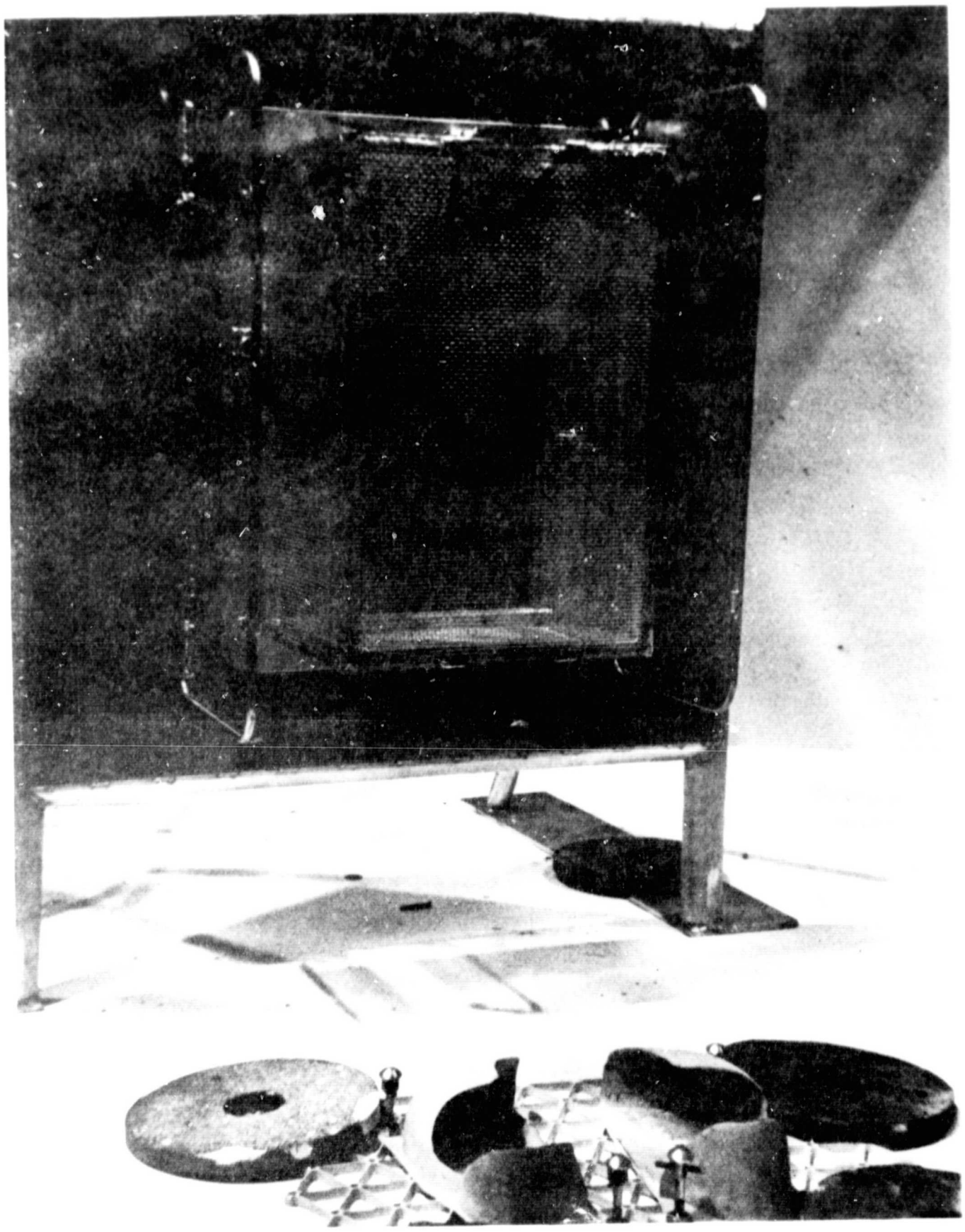

FIGURE 2. DETACHABLE ALUMINUM TASK PANEL

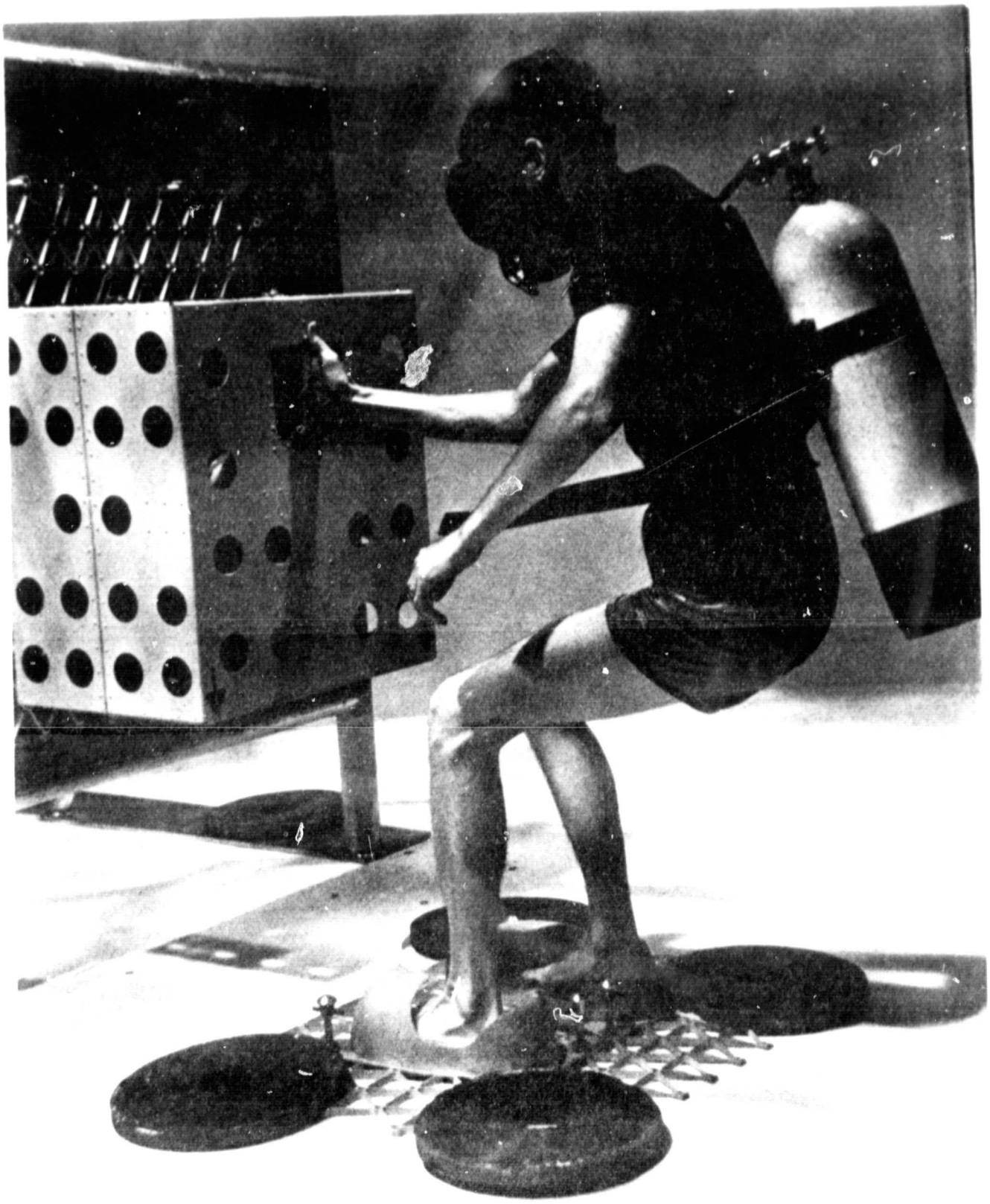

FIGURE 3. DOUGLAS GRID AND HOOK CONCEPT

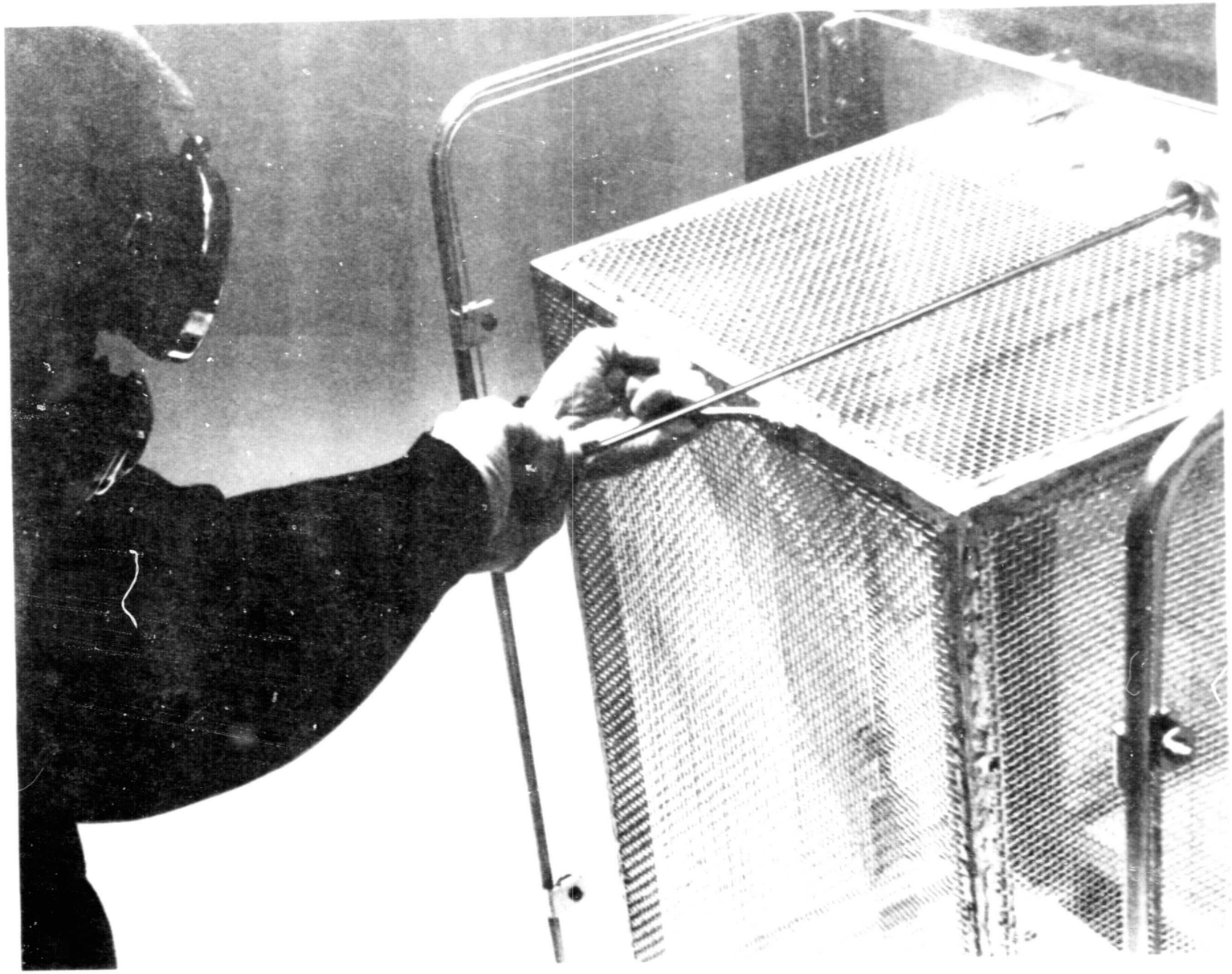

FIGURE 4. McDONNELL CAPTIVE SCREW CONCEPT

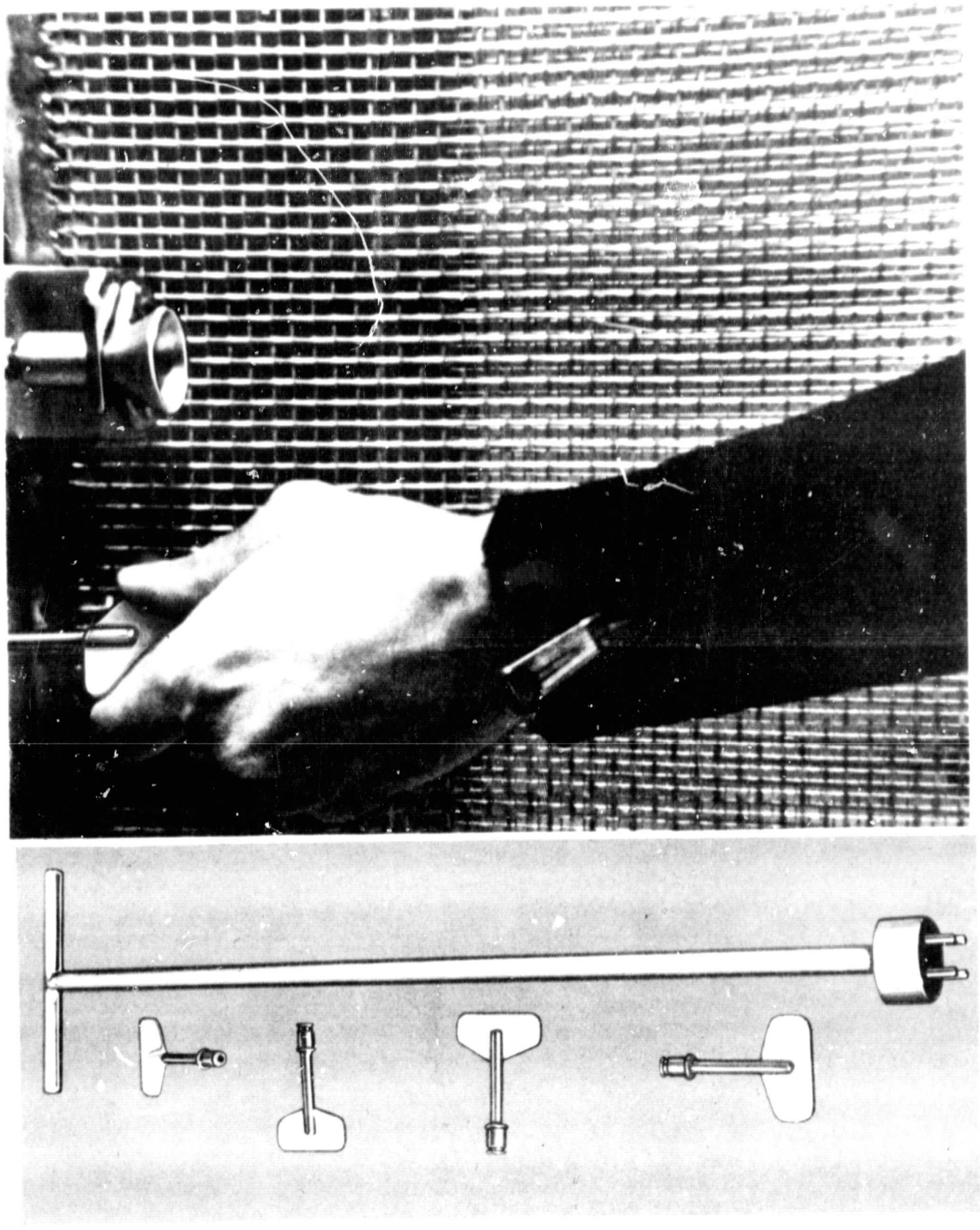

FIGURE 5. MARTIN DEUTCH SCREW CONCEPT

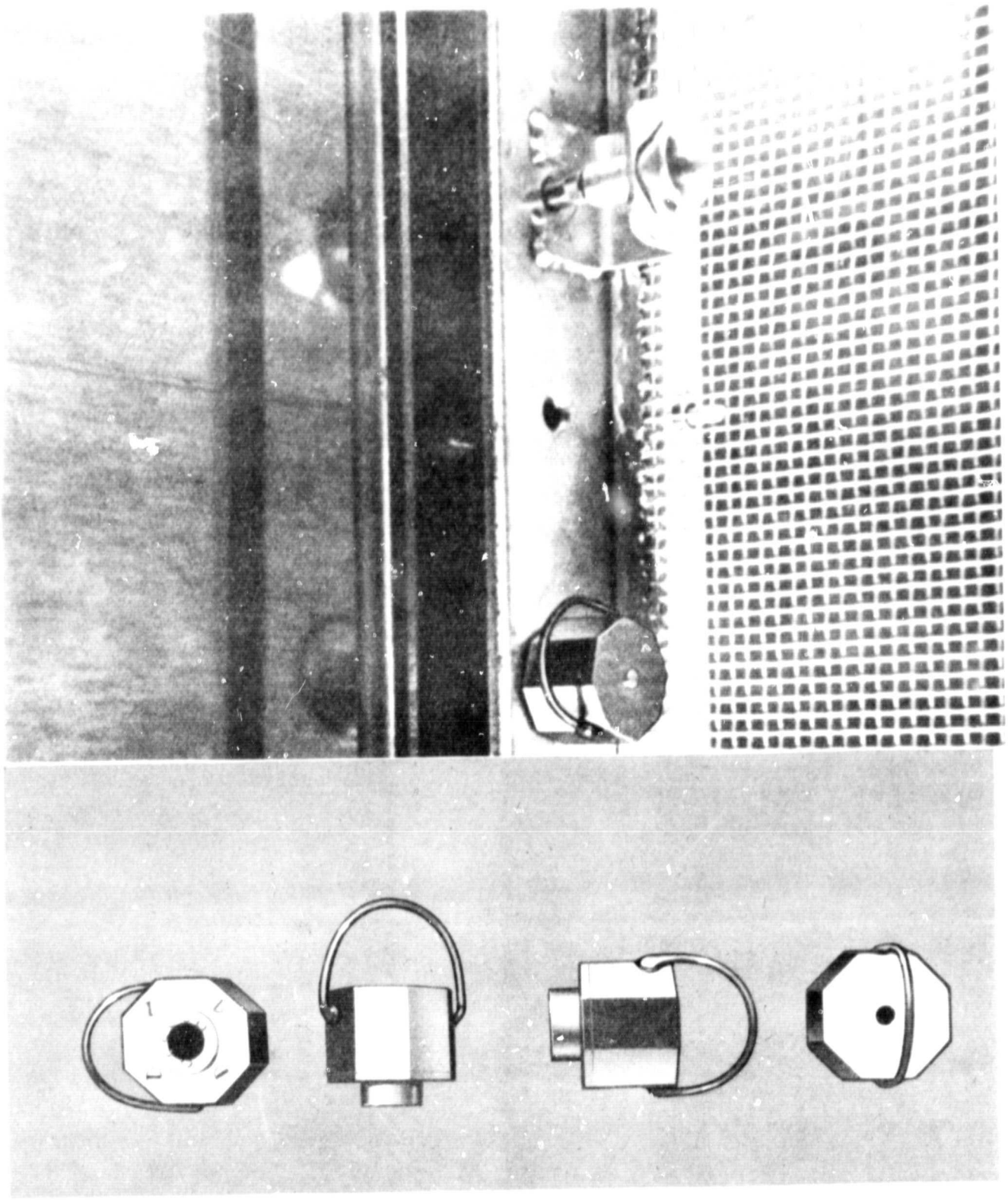

FIGURE 6. MSFC QUICK-RELEASE NUT